Status Update on Simulations for Far Forward Detectors at eRHIC

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EIC Task Force Meeting

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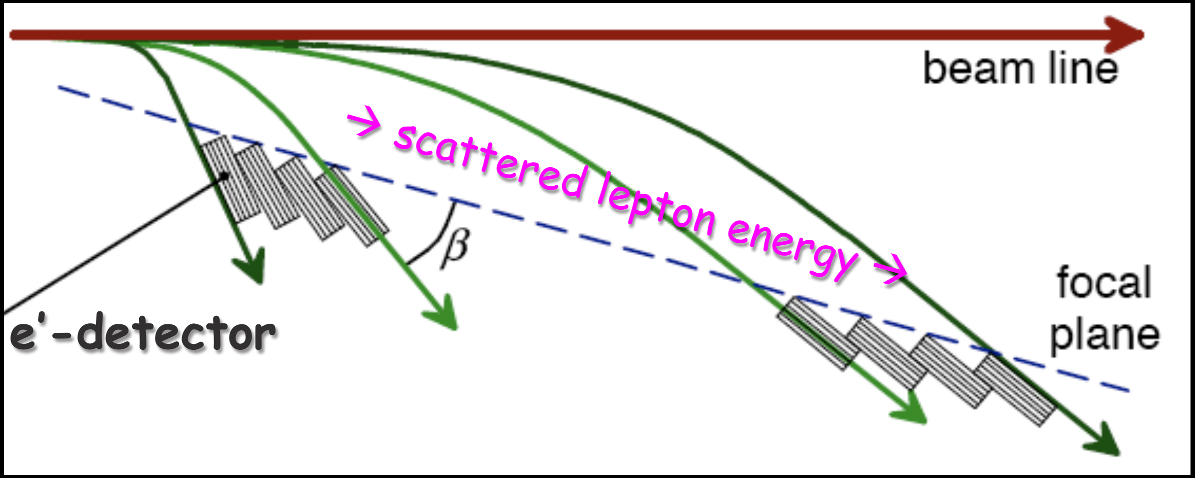
Outline

- Low Q^2 tagger simulation status
  - low Q^2 tagger at very backward angle to measure low angle scattered electrons
  - initial detector design and geometry
  - integration in IR at CAD feedback
  - initial scattering angle reconstruction code and results
  - next steps
- Roman Pots simulation status
  - roman pot at very forward angle to measure low angle scattered protons
  - acceptance studies with the new IR setup (v2.1)

Low Q^2 Tagger

- very first design from a few months ago
  - offshoot from JLab Hall D tagger



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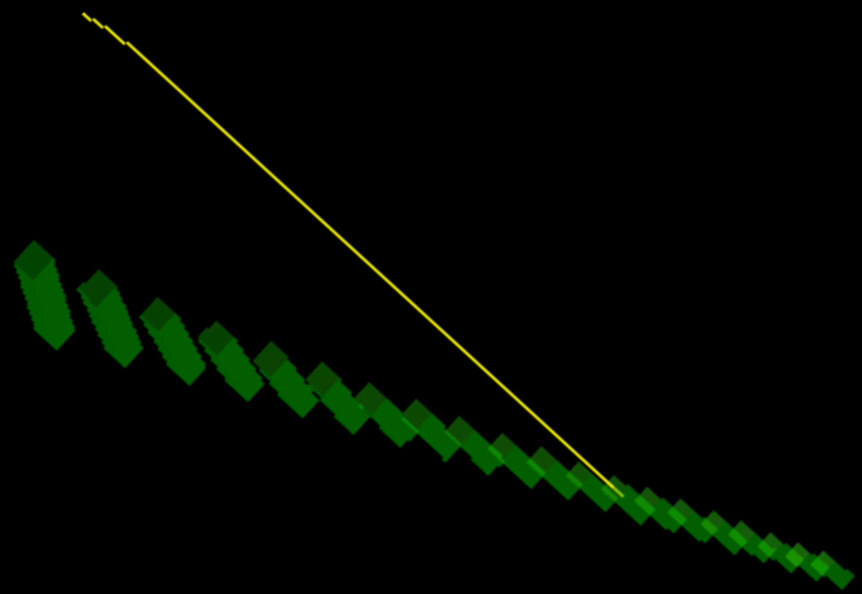

- no IR implementation at this point, simply implement an arbitrary dipole field

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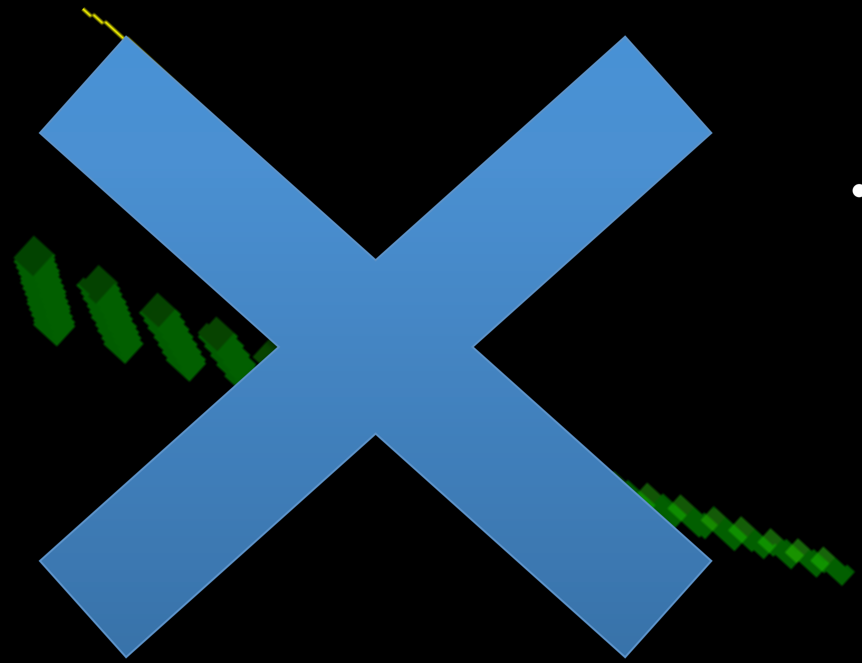
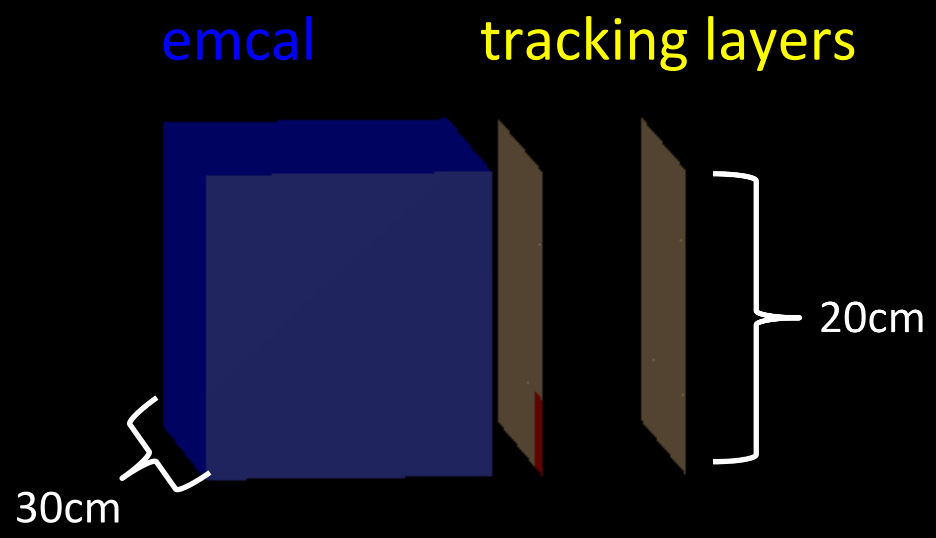


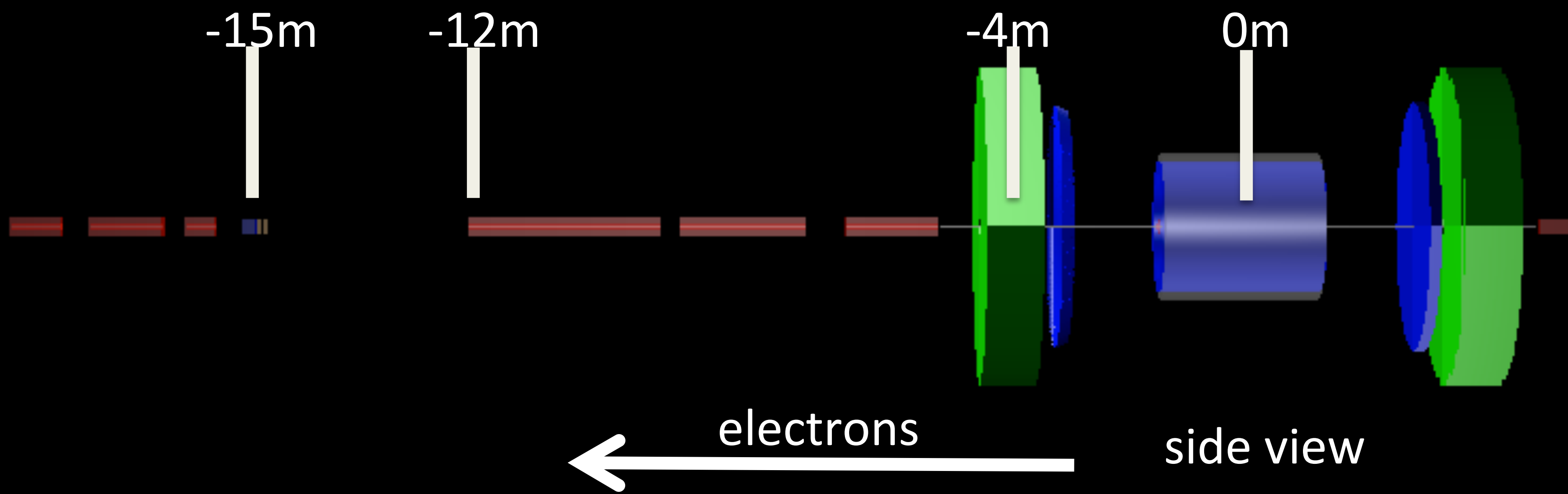
- won’t work with our IR design and fields

Current Design

- Compact detector system comprising of:
  - 2 tracking layers -> reconstruct θ
    - each layer consists of a 6x4 array of $5cm^2$ cells and 400um thick
  - emcal -> reconstruct E



Integration into the IR (v2.1)



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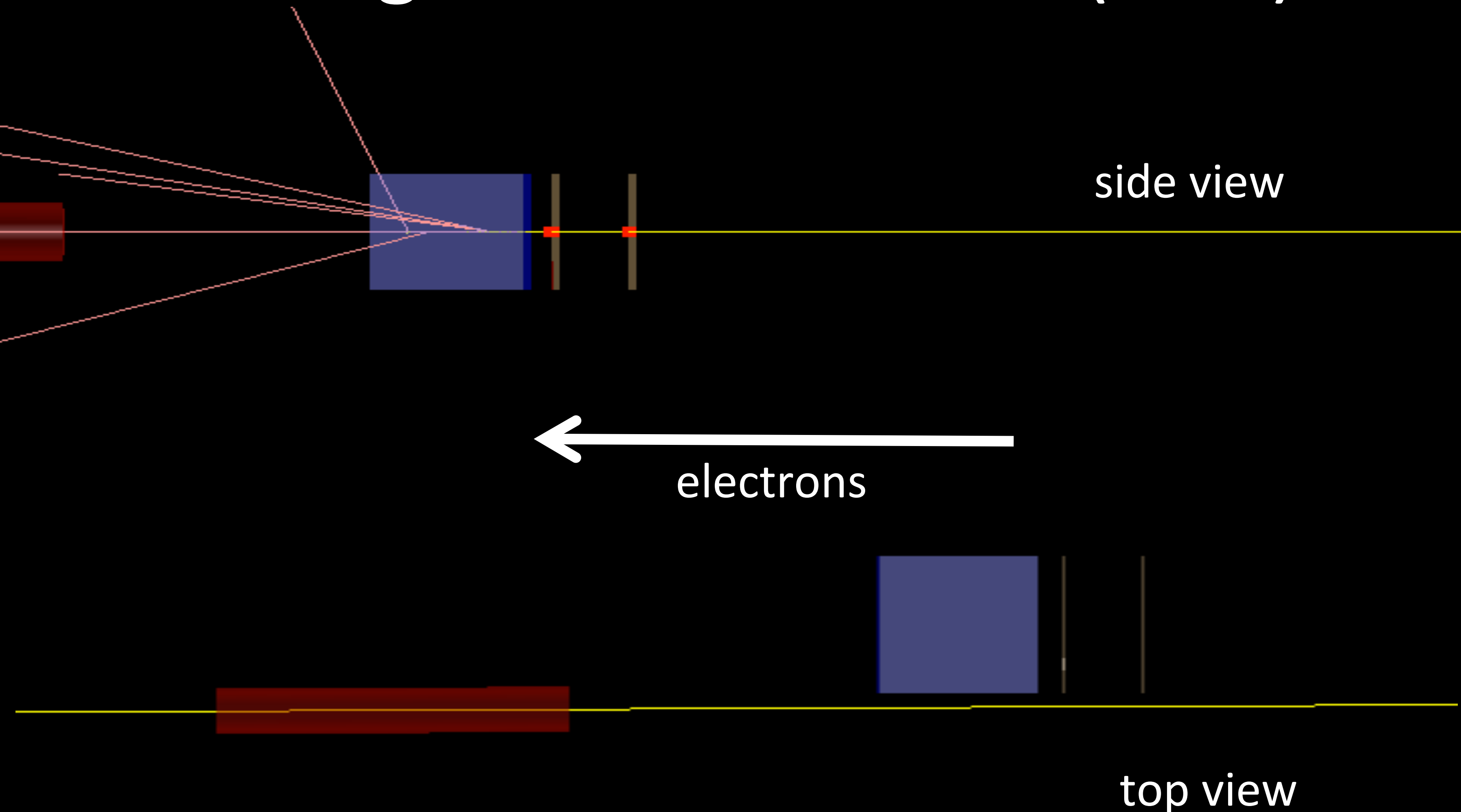
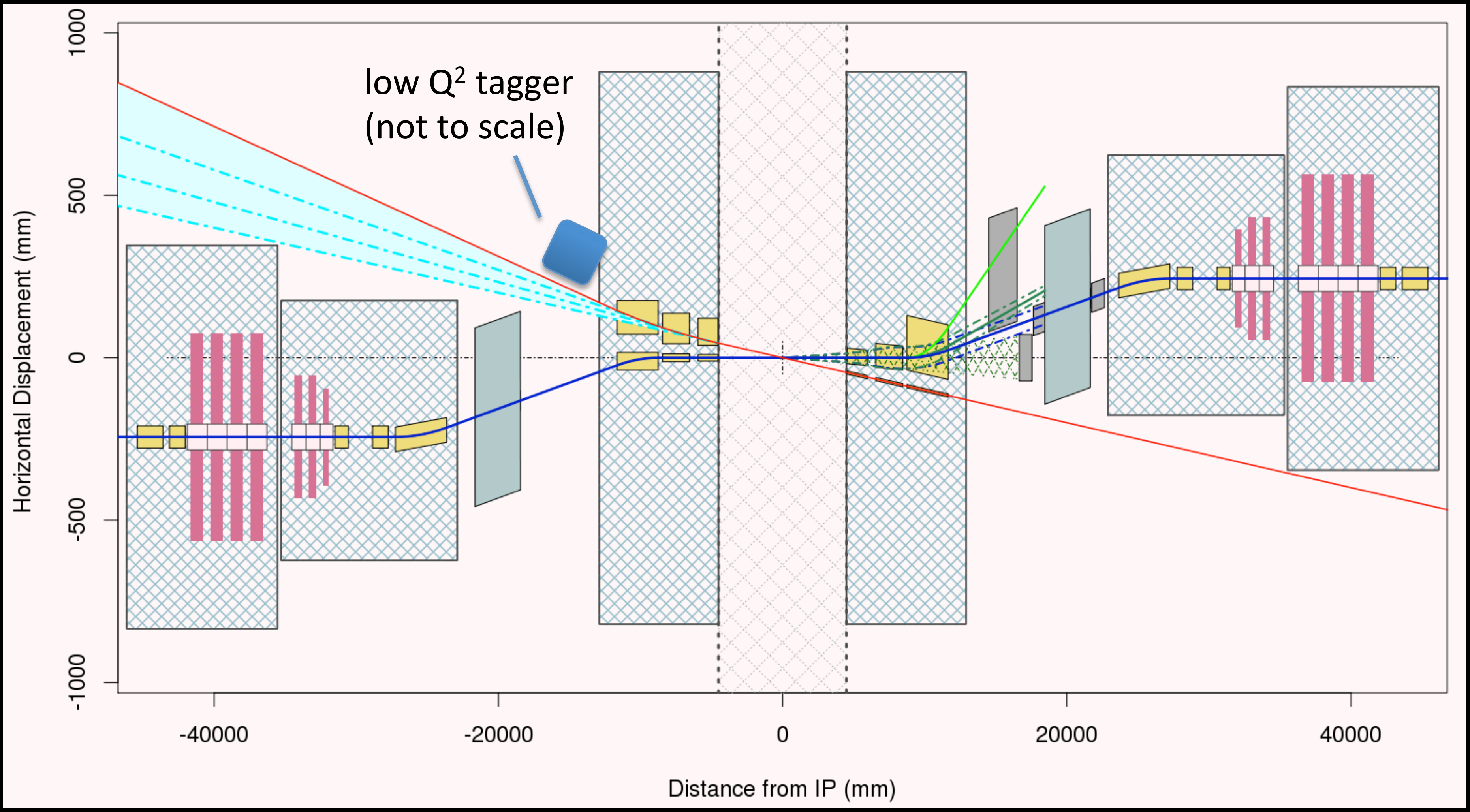


Acceptance Studies with Current IR Design

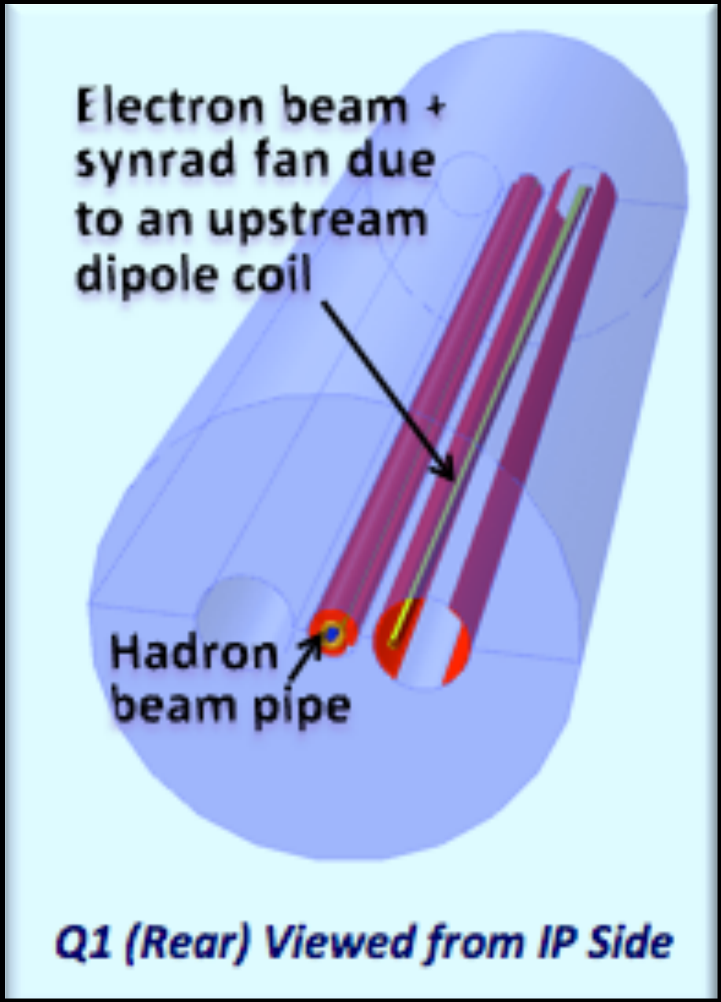
- The acceptance of low scattering angle electrons is limited by:
  - beta function: how close can the detector go to the beam to access the smallest angles
  - magnet apertures in quads and dipoles
    - we can do something about this fairly easily
    - currently communicating with Brett Parker of CAD
    - see IR schematic on next slides

Schematic of the IP



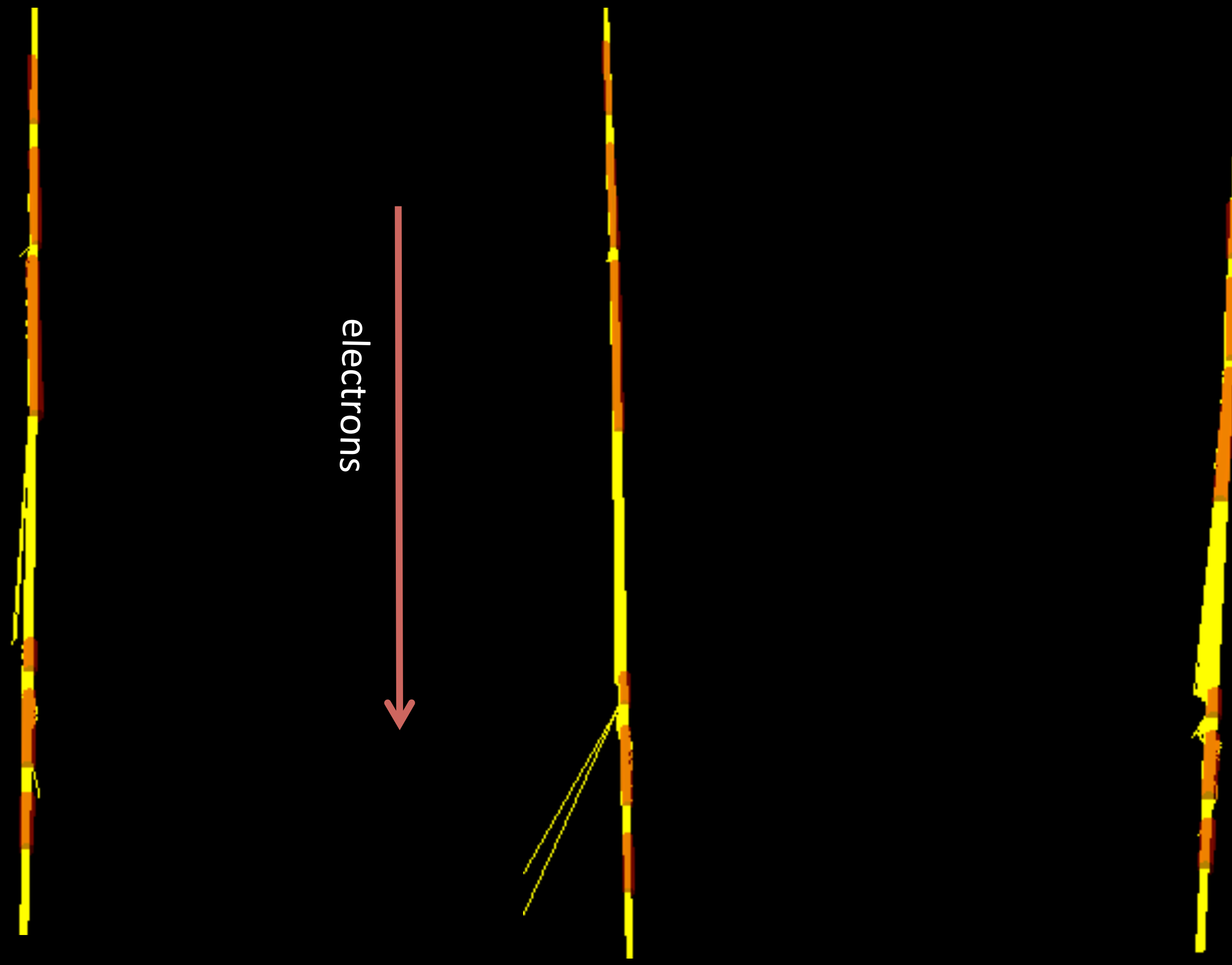
More beam line design

- electron beam line passes through the yoke common to the hadron triplet
- 4.5 – 5.2cm radial aperture for electron beams
- meant to increase experimental acceptance
- current v2.1 design has electron aperture parallel to hadron beam (and aperture)
  - electron beam crosses at an angle of 10mrad
  - this limits the acceptance and we can do better
  - will show rotating the orientation of the aperture can increase acceptance

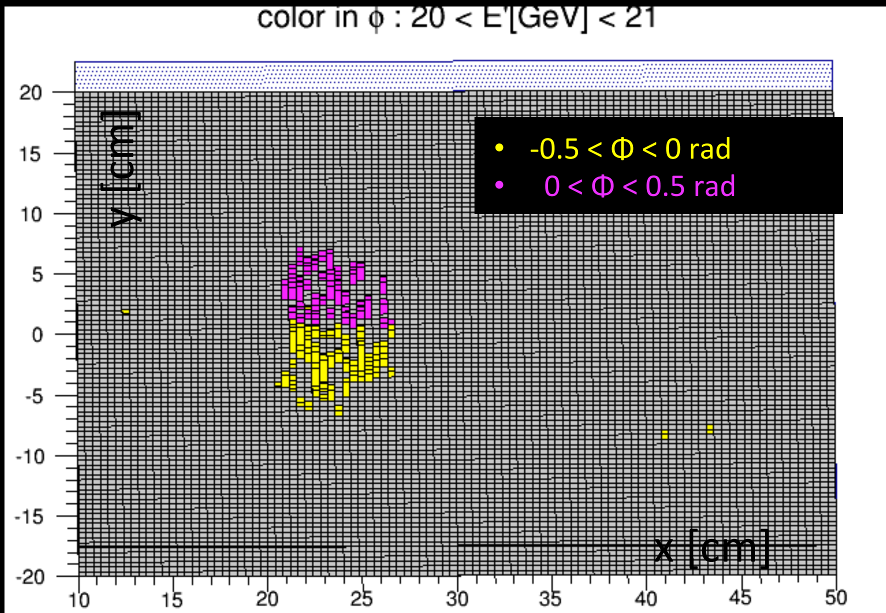


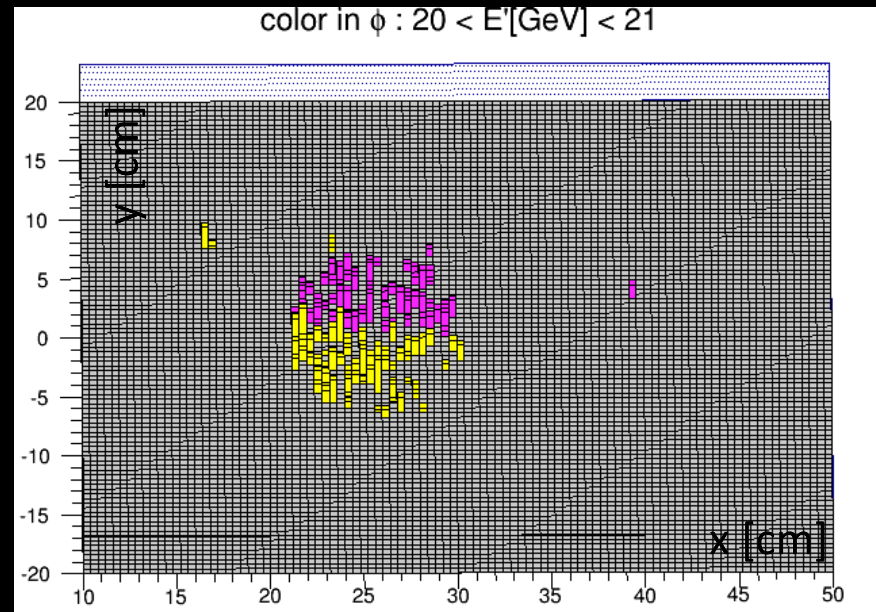
playing with the aperture (E’ = 20 GeV)

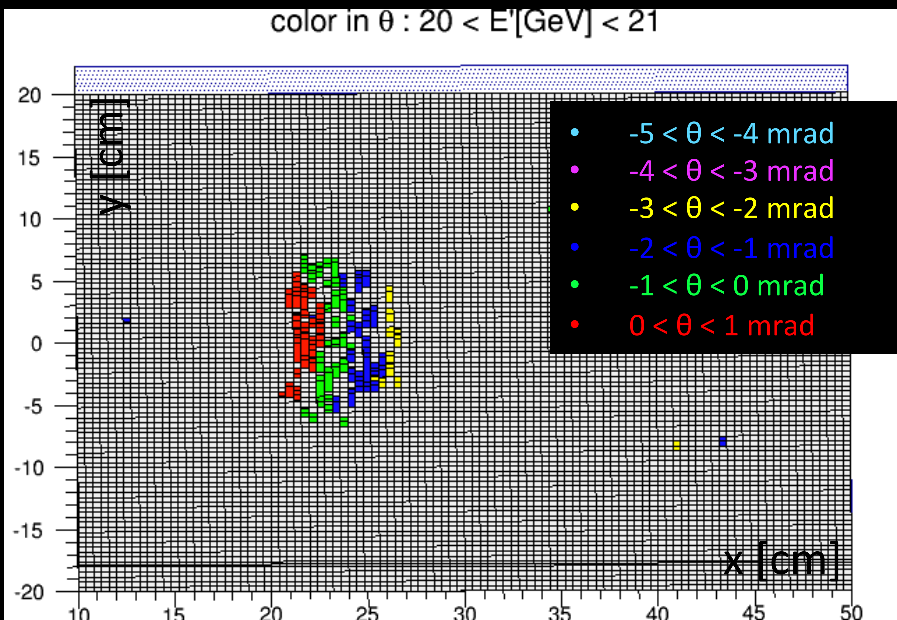
nominal design   20 mrad rotation (+10cm shift in x)   30 mrad (+ 10cm in x)

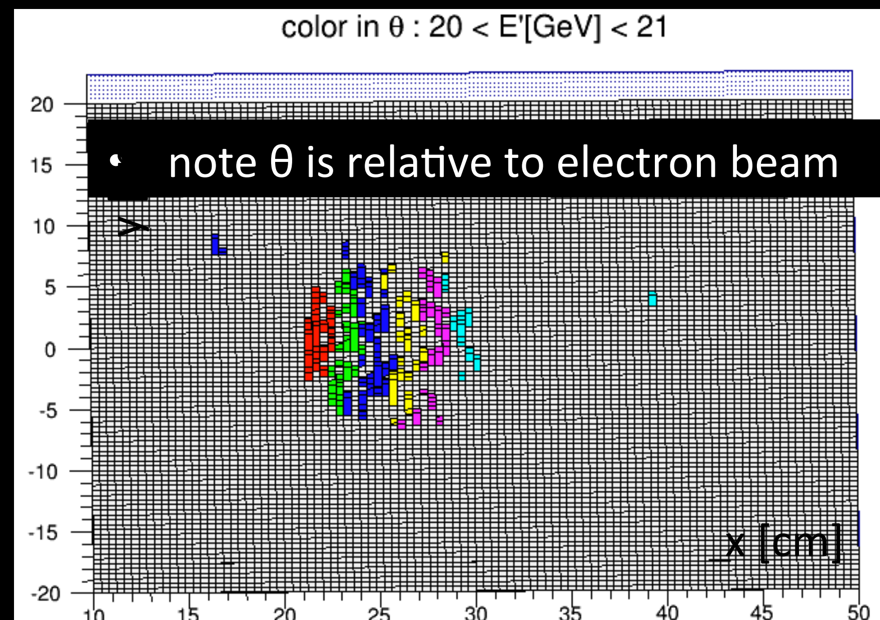


Comparing nominal design to my 30mrad aperture rotation (just the final aperture) on hit plane

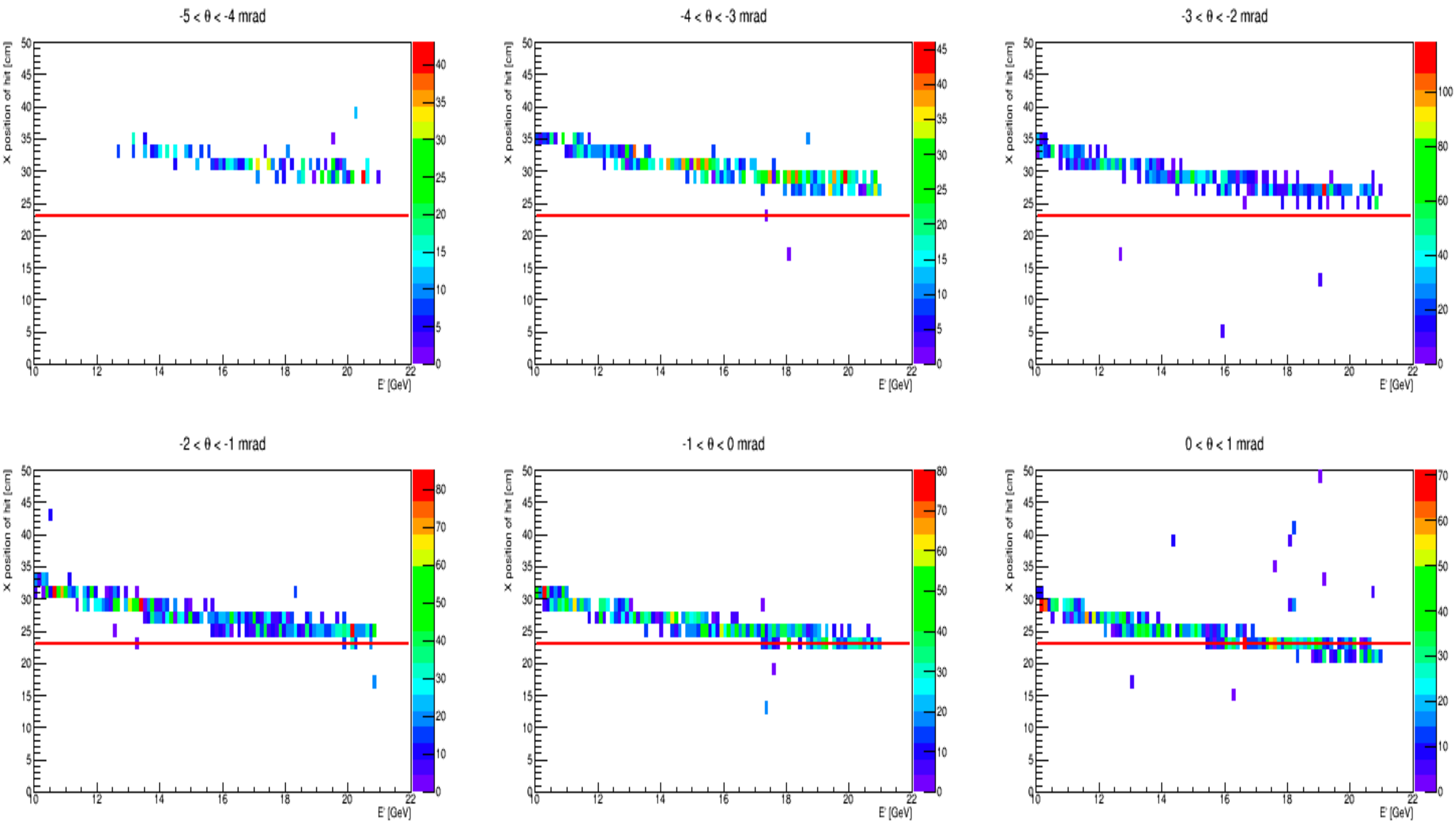




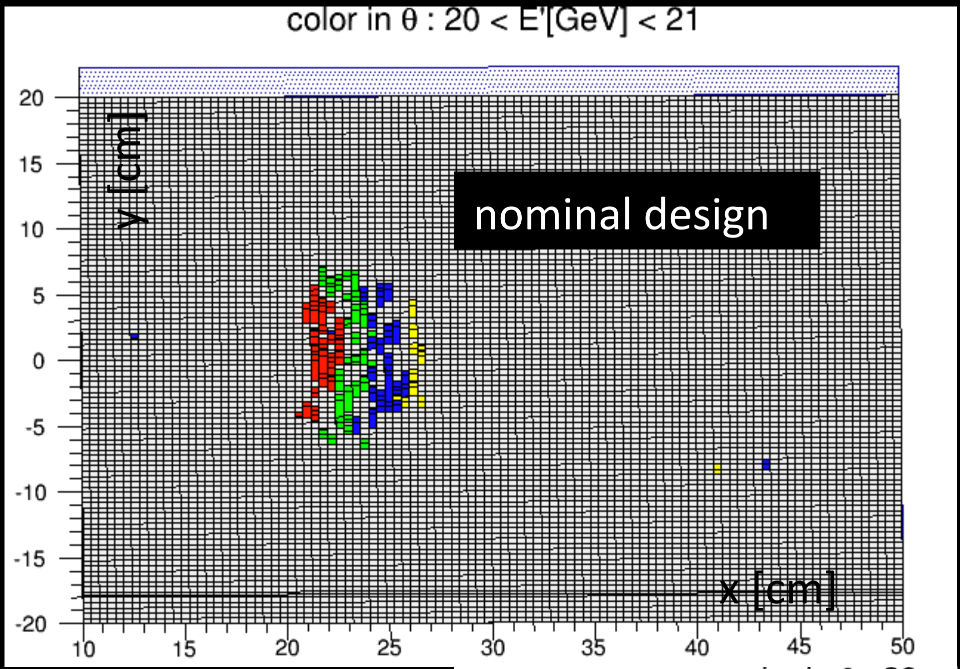


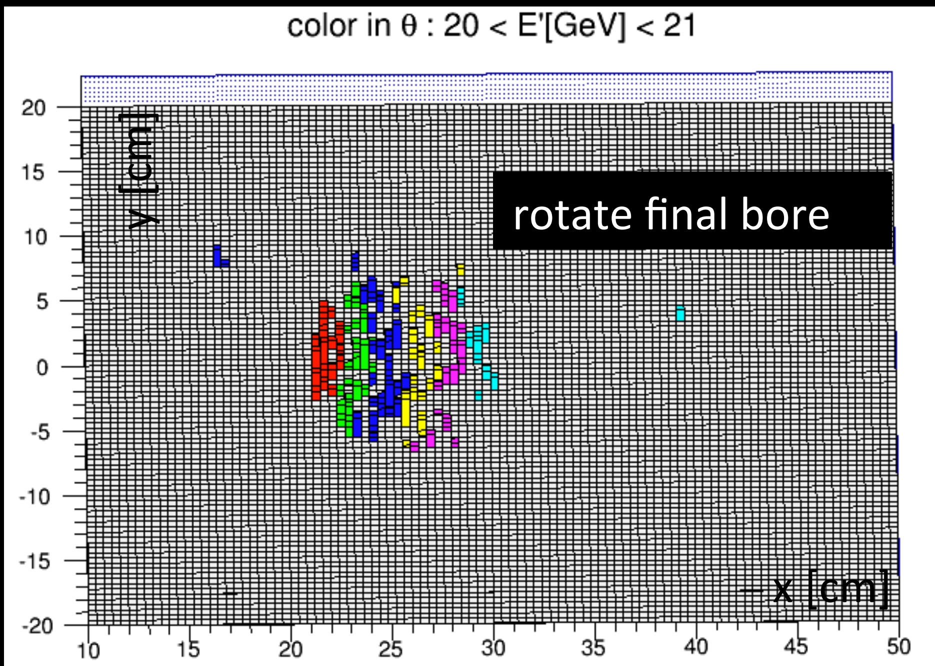


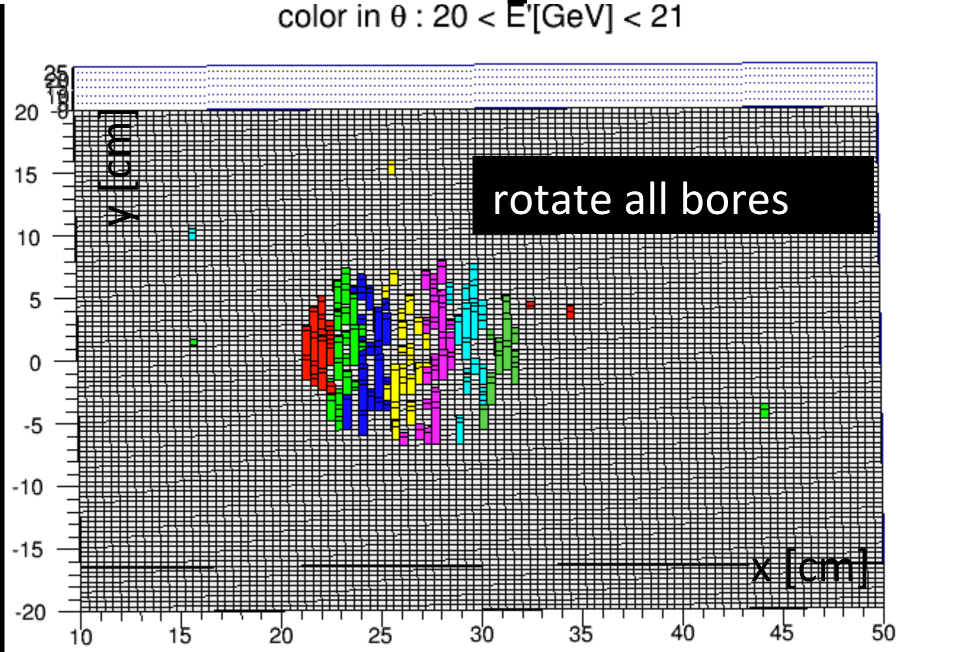
x position vs E’ in bins of scattering angle theta for the 30mrad rotated aperture



One more bore tweak





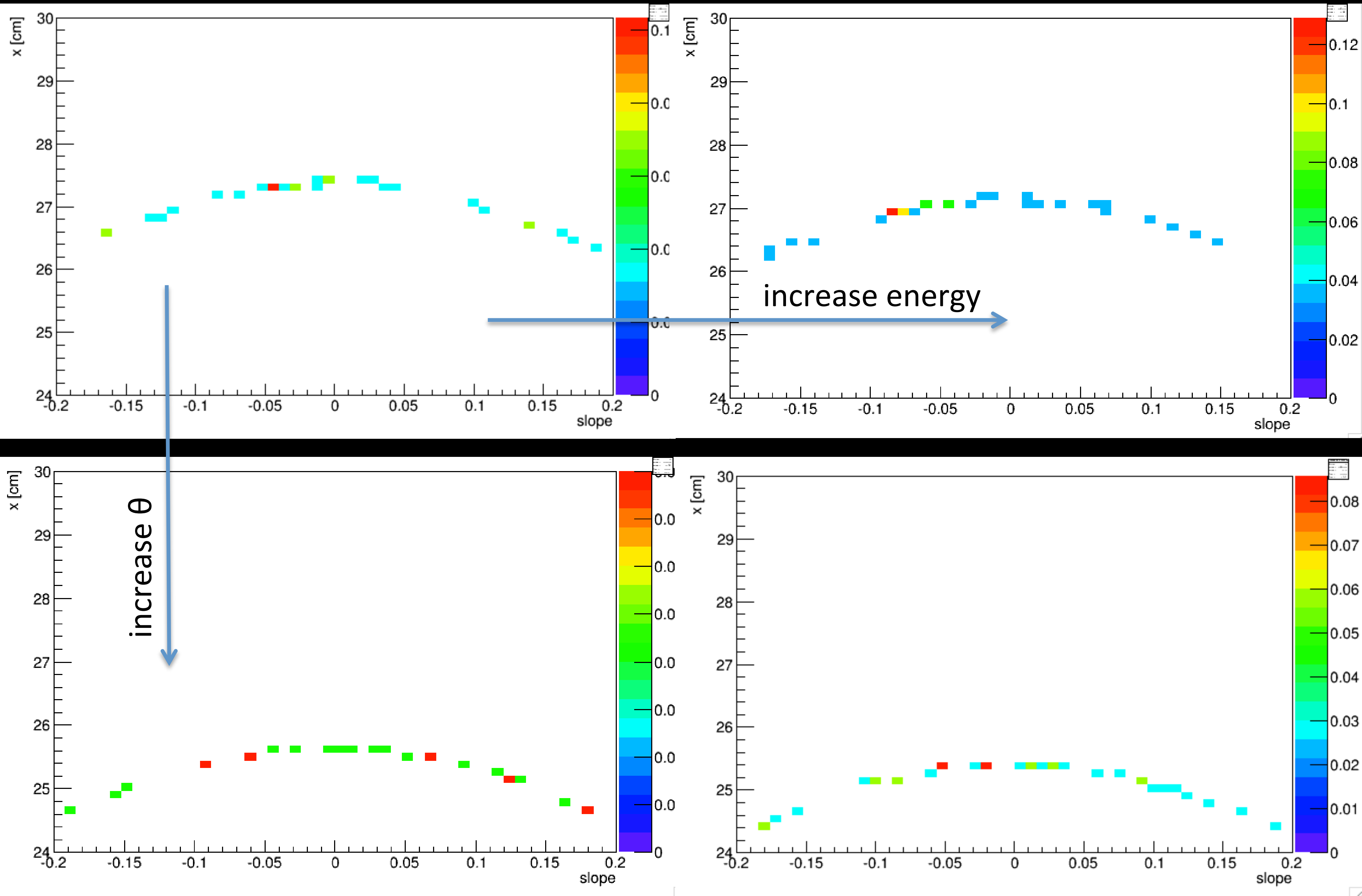


- -6 < θ < -5 mrad
- -5 < θ < -4 mrad
- -4 < θ < -3 mrad
- -3 < θ < -2 mrad
- -2 < θ < -1 mrad
- -1 < θ < 0 mrad
- 0 < θ < 1 mrad

Latest Code Developments for Low Q^2 Tagger

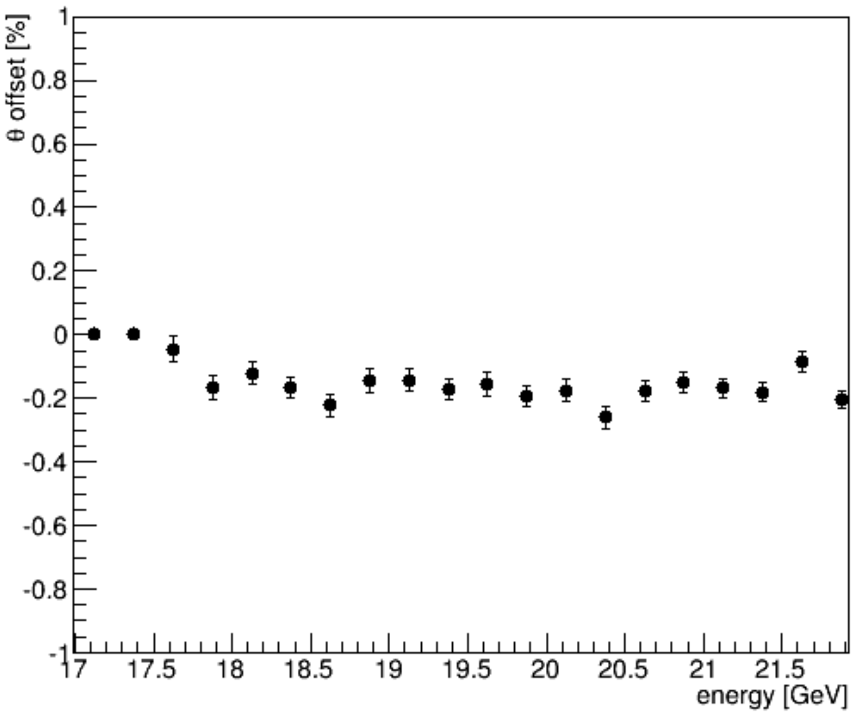
- EicLowQ2Tagger class for detector implementation in EicRoot
  - eicroot/eic/detectors/lqst
  - details in backup slides
- Scattering angle, θ, reconstruction code developed
  - implemented with "look up tables" in the form of histogram maps
  - fill histograms of slope vs x_1 hit in bins of energy and θ and normalize per number of events
  - for a given energy, poll each θ histogram for the corresponding slope, x_1 bin
  - θ is chosen as the bin with the largest histogram value
  - randomize within the bin width to remove discretization

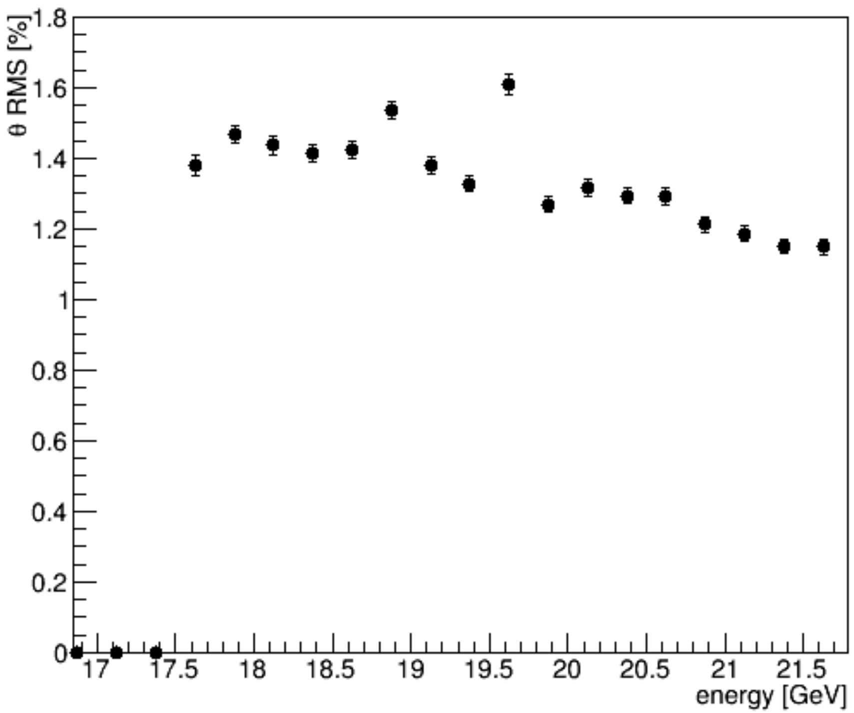
Example look up table histograms for θ reconstruction



Scattering Angle, θ, Reconstruction Performance

- shift probably due to needing more stats for histogram training





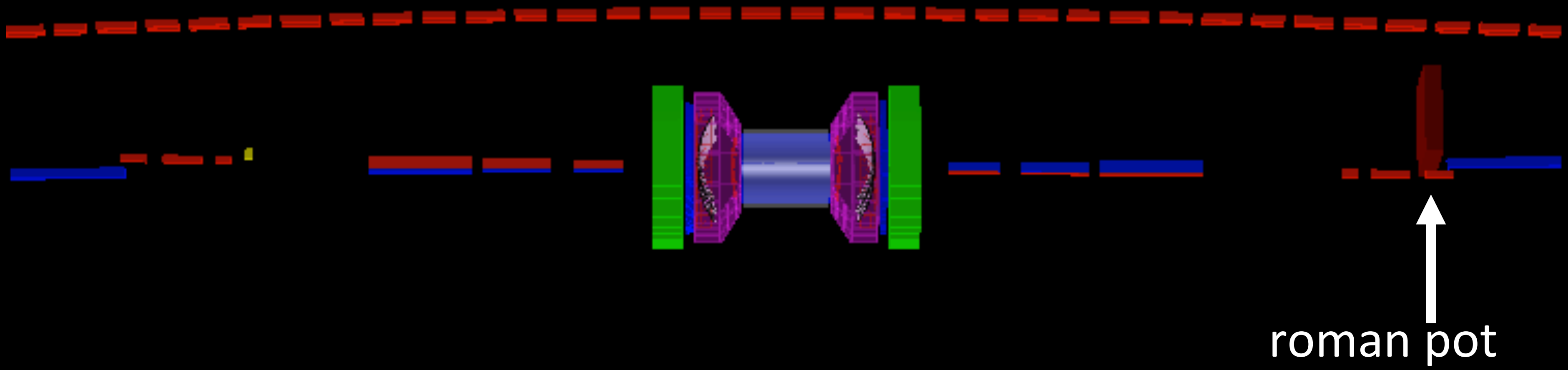
Future Improvements for Low Q^2 Tagger

- Add a layer of digitization accounting for segmentation of sensor pixels
- Implement a realistic emcal response for energy reconstruction
- Fold both these effects into the θ resolution as well as Q^2 resolution
- Implement a full beam pipe to observe the effect
- One thing to check: simulation is done with only the electron beam installed, will results be different if both beams are installed simulatneously?

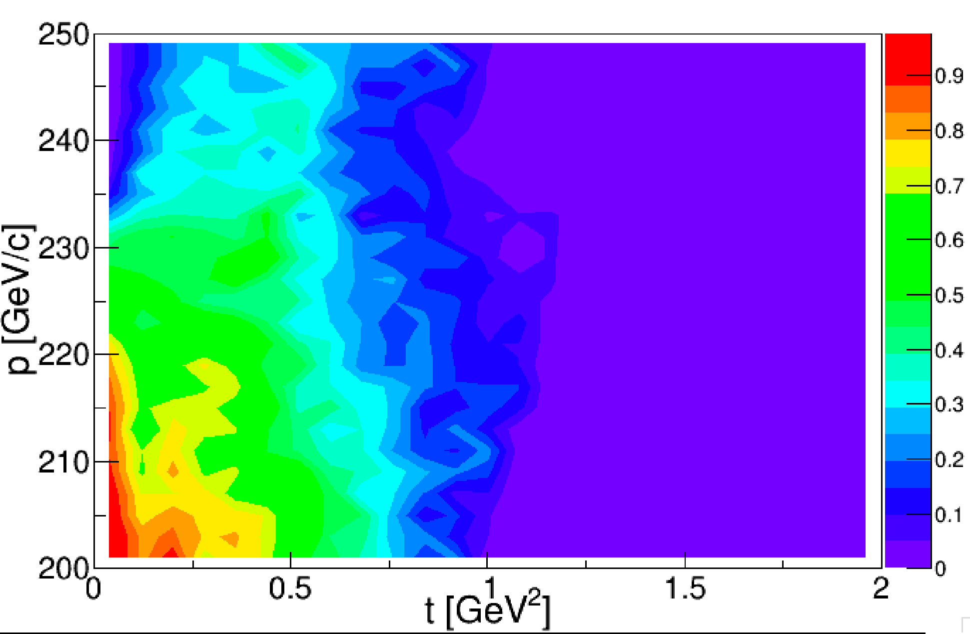
Roman Pot Acceptance Studies

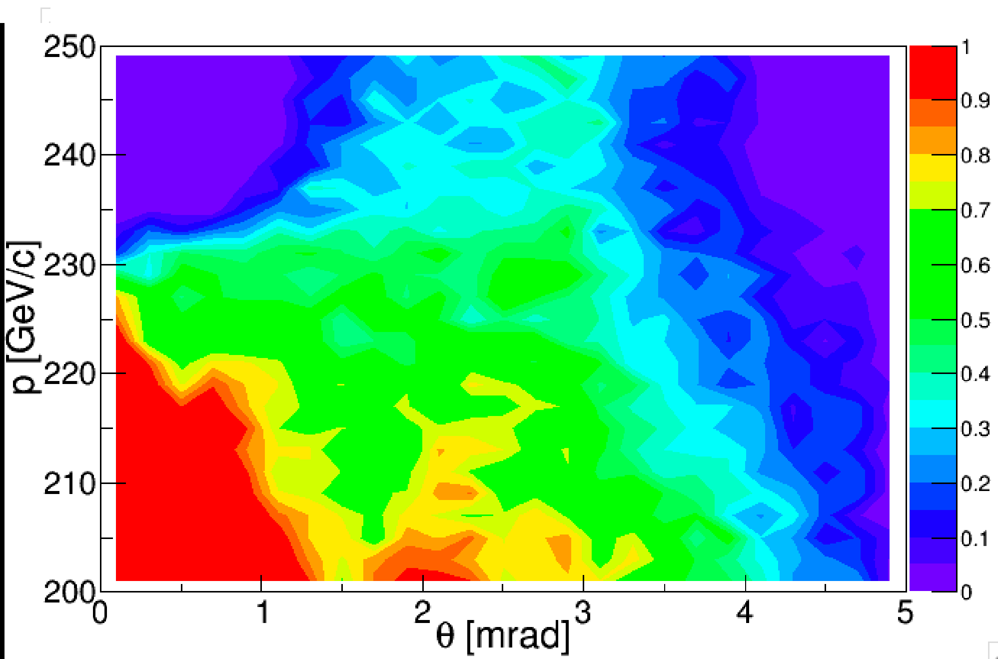
- revisit acceptance studies by JH with the newest IR design in EicROOT
- very simple detector design for this purpose
  - single large tracking sensor
  - placed at z = 18m
  - place 10σ distance from beam (1.2cm at 18m)
  - only placed on one side of the beam
    - will not fit on other side b/c of electron beam
    - but could cover directly above and below beam
- simple particle simulation
  - simulate single particles (not full DVCS events)
  - throw flat in p, θ, ϕ, but weight (semi)realistically θ
  - in DVCS, $t \approx p_T^2$ of scattered electron and so t in the following plots is actually p_T^2
  - include 20% energy loss of electron (which is distributed flat)

Roman Pot Design in Current IR (v2.1)



Roman Pot Acceptance





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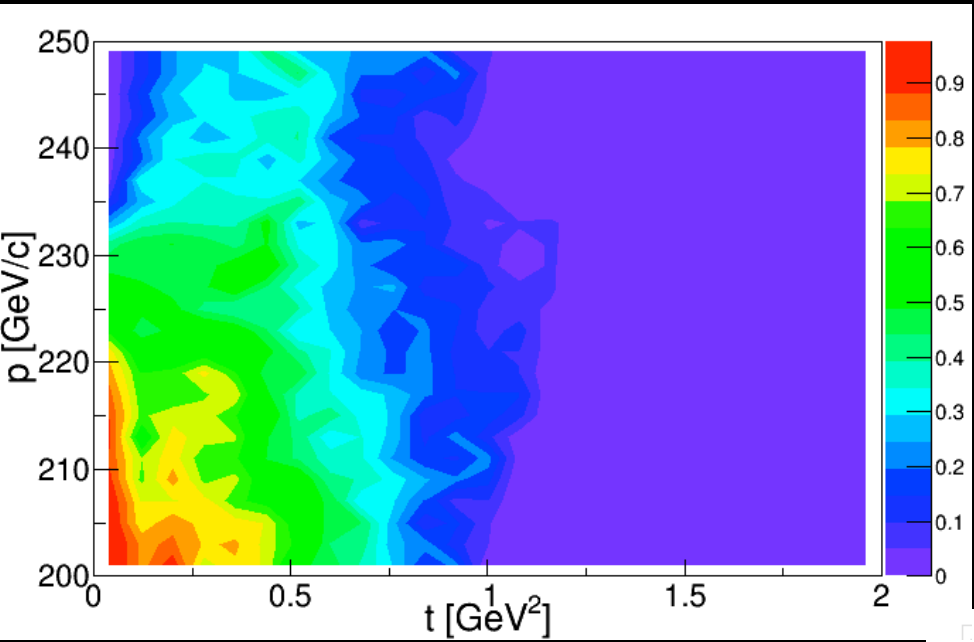
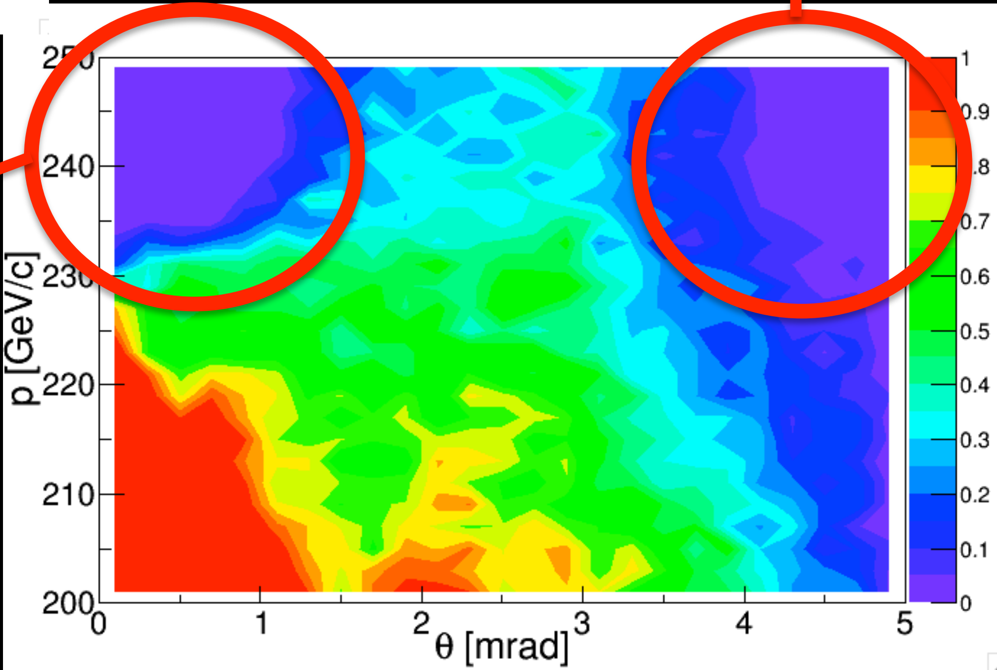
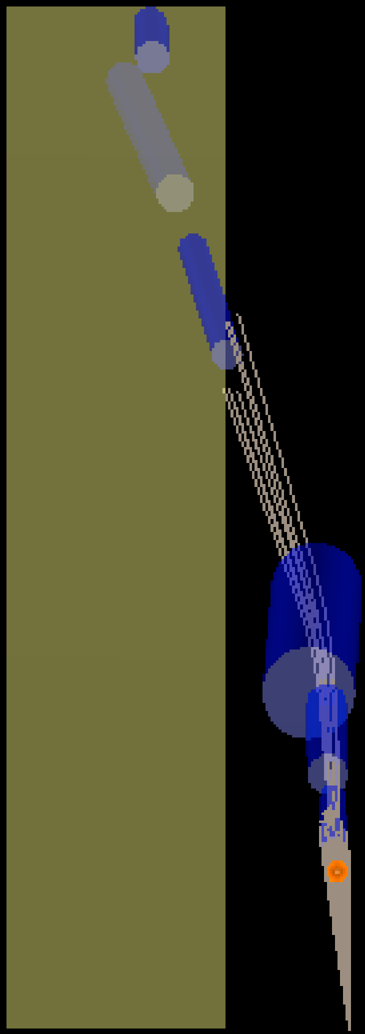


- seems to be lost in magnet yoke (see next slide)
- can work with CAD to improve

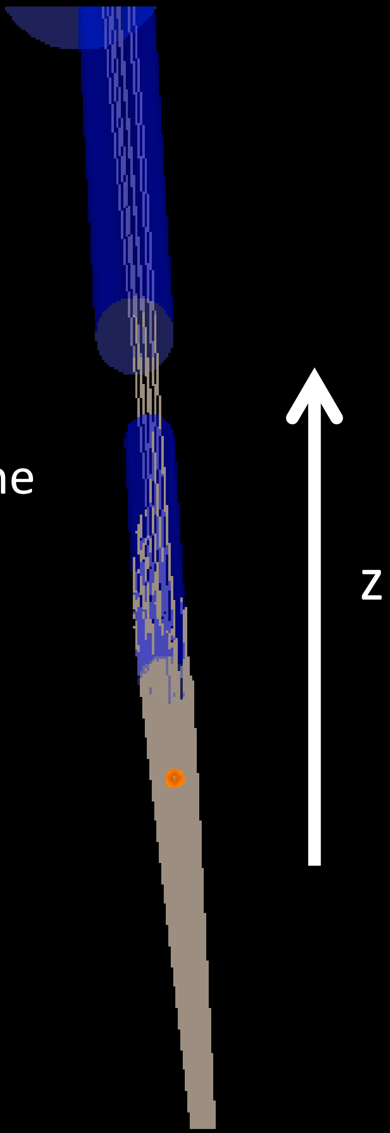


- possibly gain with a station very far down (>40m)
- still need to look into this

Losing Acceptance at High t

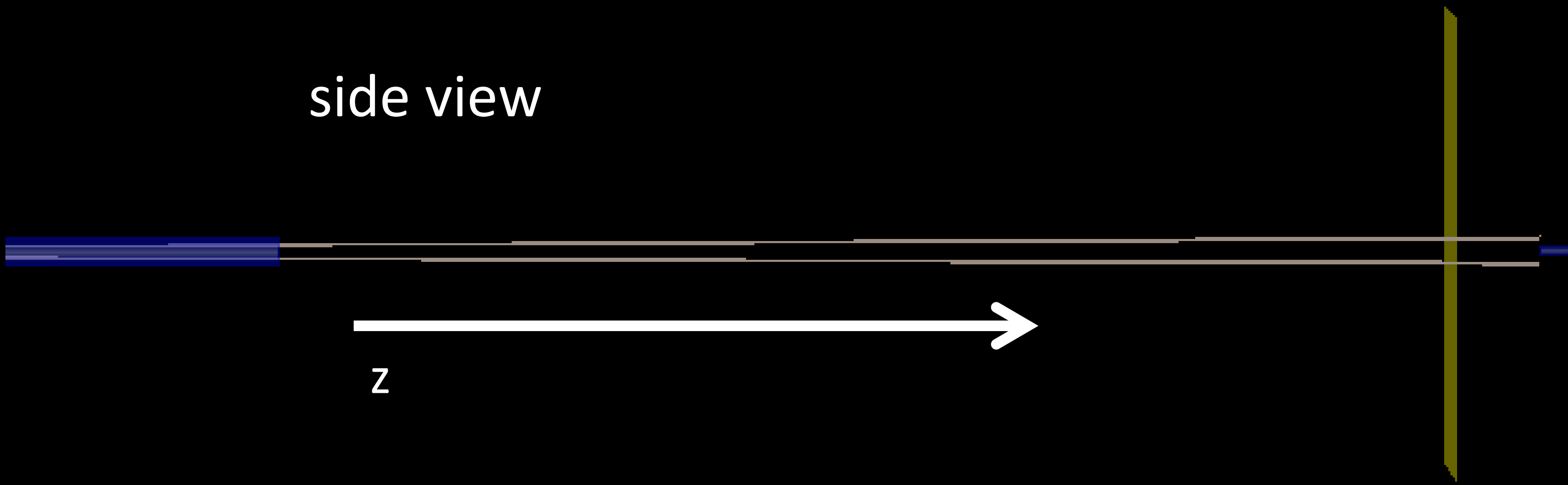


- generate 100 protons in the range 240 < p < 250 GeV/c and 4.5 < θ < 5 mrad
- many tracks hit magnet yoke in the first quad magnet
- a handful still make it through



Losing Acceptance at High t

- may be able to reclaim some of the lost acceptance at high t by covering directly above and below beam



Future Improvements for Roman Pot

- Explore effect of adding stations very far down
  - still need to work out where these may go exactly
- One thing to check: simulation is done with only the electron beam installed, will results be different if both beams are installed simultaneously?

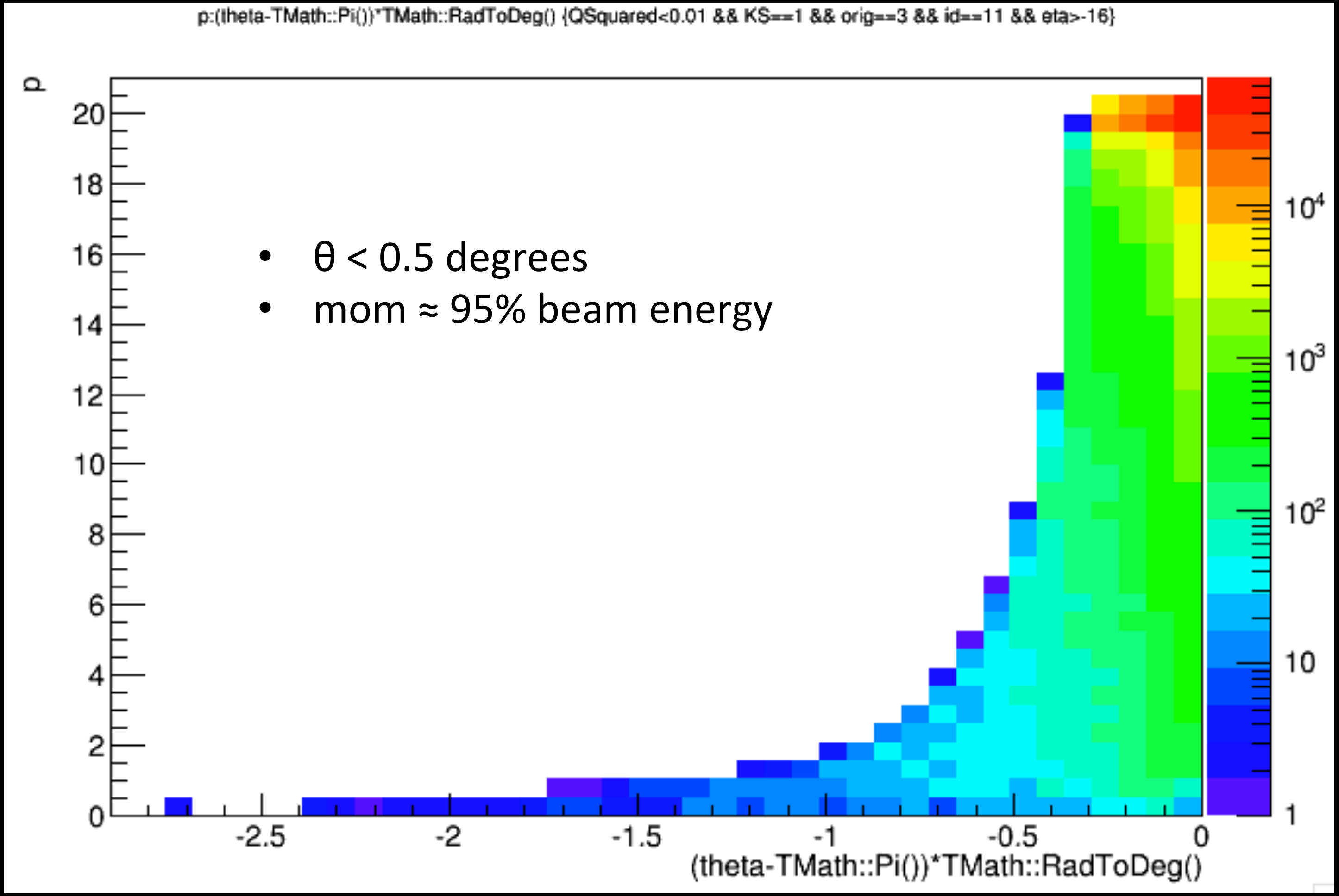
Summary

- Significant progress made in design of far forward detectors integrated in v2.1 of IR design
- Low Q^2 tagger
  - have an intial design
  - studied acceptance in IR and working with CAD for the next iteration in the design
  - have initial θ reconstruction software in place
- Roman Pots
  - repeated previous acceptance studies with the current IR design
  - acceptance is good, working to improve at high t

Backups

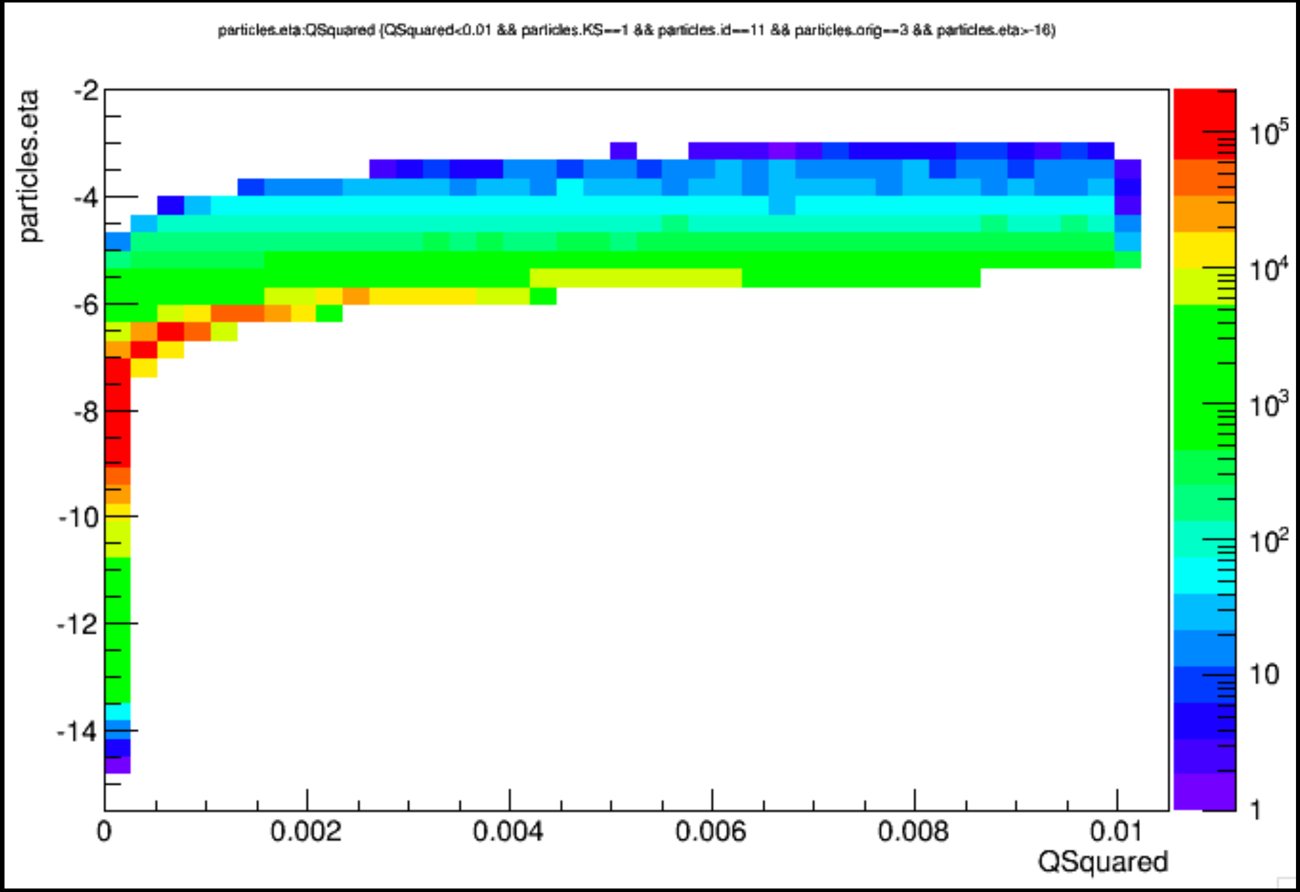
Acceptance: What does Pythia say?

- 20 on 250GeV e+p collisions
- scattered electrons are dominantly at beam energy and scattered less than 0.5 degrees for $Q^2 < 0.01$ events



Pythia Simulation Characterizing Low Q^2 Events

- Take a quick look at existing pythia TTrees on disk
  - /eicdata/eic0004/PYTHIA/ep/NEWTREES/10x250.5Mevents.1.RadCor=0.root
  - plot eta vs Q^2 of the scattered electron below



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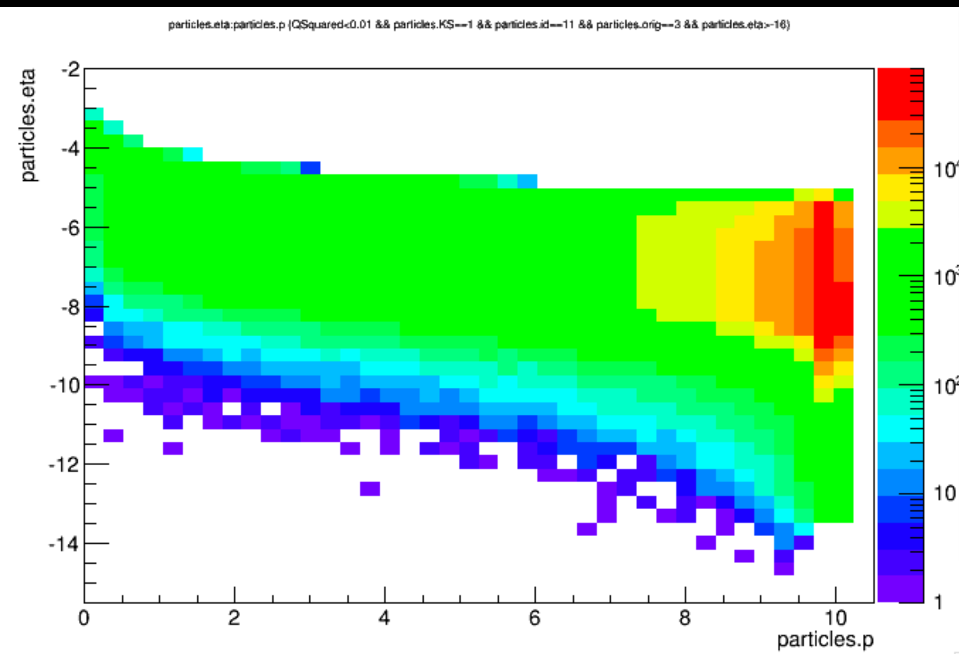
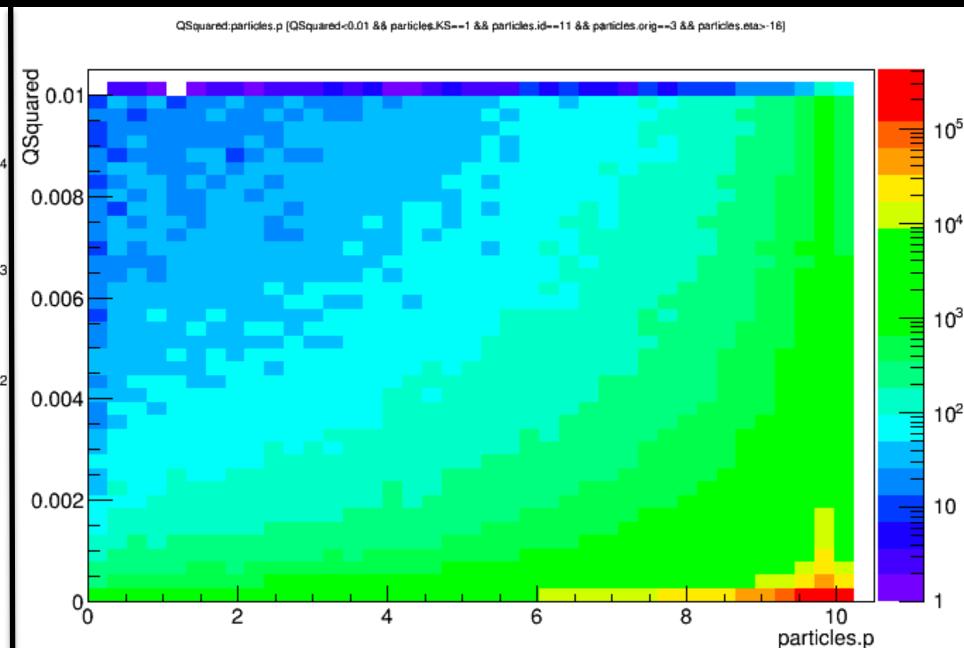
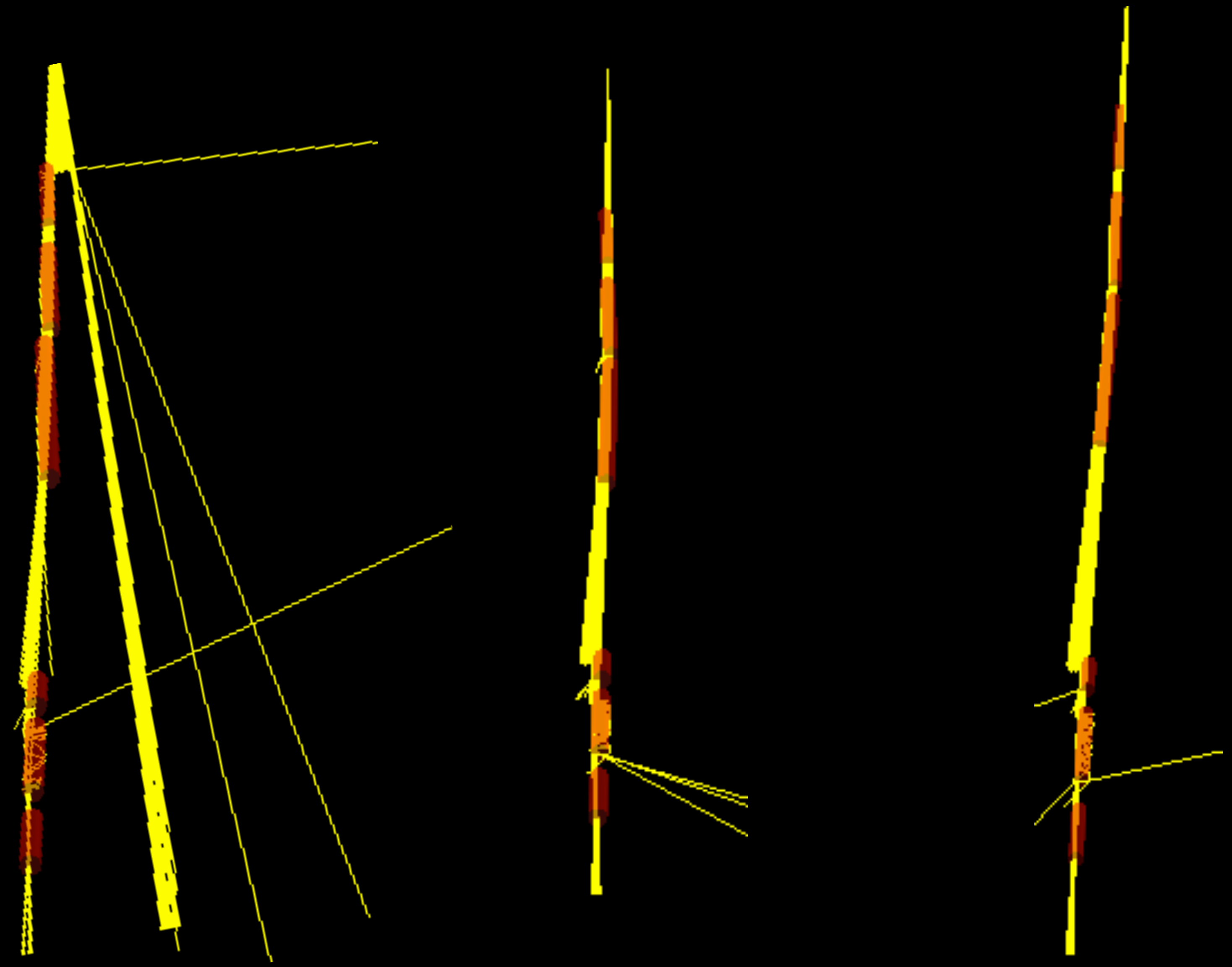
- plot momentum of the scattered electron below



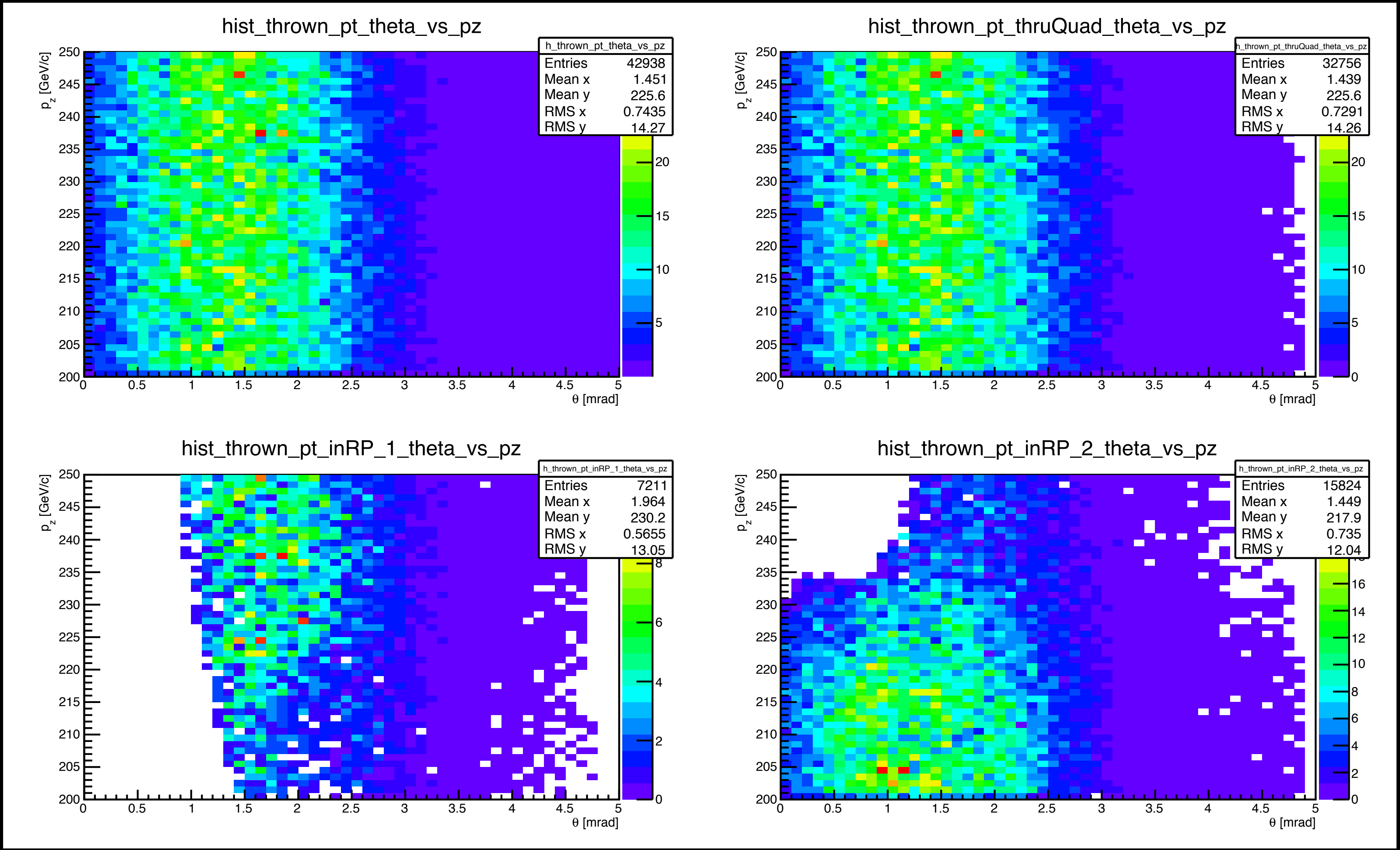


playing with the aperture (varying energy)

nomimal design 20 mrad rotation (+10cm shift in x) 30 mrad (+ 10cm in x)

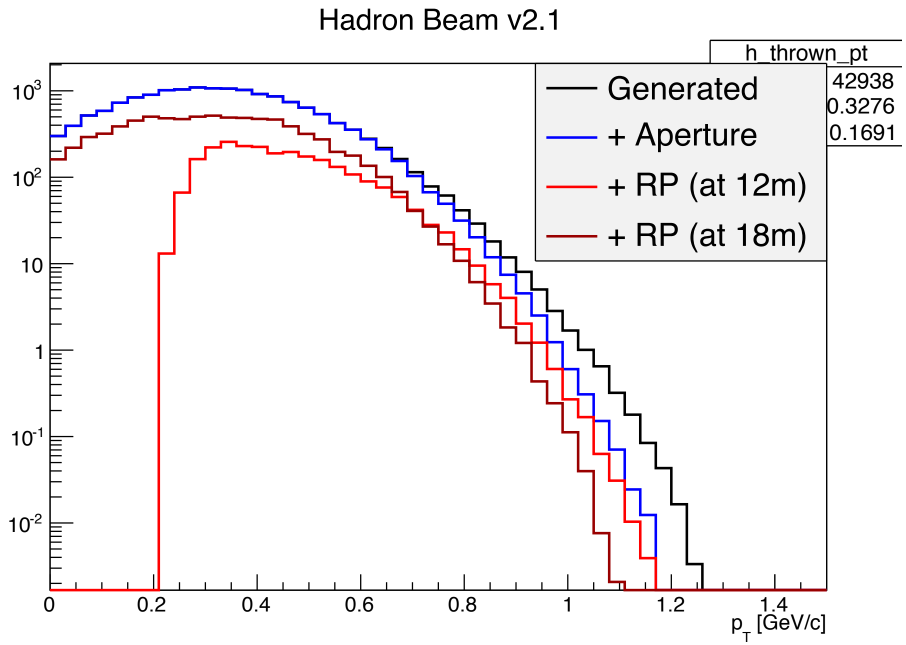


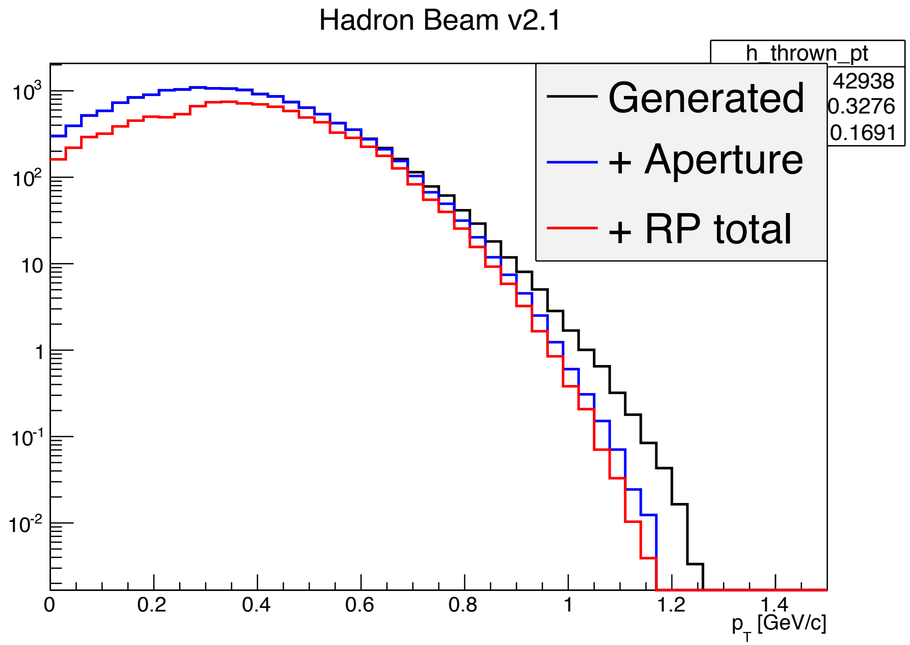
Roman Pot Acceptance



Roman Pot Acceptance Due to Aperture and Detector

- 2 stations in this simulation
- placed on both the left and right side of the beam
- one at 12m, one at 18m





Thrown t in simulation